Miniature Photonic Spectrometers and Filters for Astrophysics and Space Science

Completed Technology Project (2018 - 2020)

Project Introduction

This project seeks to apply our recent breakthroughs in astrophotonics - photonics applied to astronomical instrumentation - to replace the large lenses, mirrors, and gratings of conventional astronomical spectrographs with optoelectronic components borrowed from the multi-billion dollar telecommunication industry. This will reduce the mass and volume of these instruments by two to three orders of magnitudes, shorten delivery times, lower the risk, and cut the cost proportionally. Photonic instruments are also more amenable to complex light manipulation and massive multiplexing, cheaper to mass produce, easier to control, much less susceptible to vibrations and flexures, and have higher throughput. The proposed effort directly addresses one of the technology gaps identified in the 2016 Cosmic Origins Technology Report, namely the need to develop "high-performance spectral dispersion components / devices." Using private funding, we have developed photonic near-infrared (1.4 - 1.6 microns) spectrometers where the dispersing optics are replaced by miniature (~1 cubic-centimeter) arrayed waveguide gratings imprinted using buried silicon nitride (``nano-core'') technology, the leading solution for low-loss waveguides. We have also developed highly sophisticated photonics filters using complex waveguide Bragg gratings, produced on the same platform technology as the photonic spectrometers and equally small. These prototypes have been fabricated and tested using the state-of-the-art facilities of the Maryland NanoCenter and AstroPhotonics Lab, and the results of these tests have been published in refereed publications and conference proceedings. APRA funding is now needed to develop the next generation of photonics spectrometers and filters for astrophysics and space science applications. We will (1) broaden the wavelength range to 1 - 1.7 microns, (2) increase the spectral resolving power of our photonic spectrometers from R ~ 1500 to 3000, (3) experiment with the aspect ratio of the waveguide cross-section and overall design of the Braggs and arrayed waveguide gratings to make them polarization-independent, and (4) increase the overall throughput of these gratings to >70% at 1 - 1.7 microns by changing the deposition method of the cladding material (silica) and reducing the scattering losses with the use of a newly commissioned electron beam writer that delivers higher resolution (down to a few nm instead of ~8 nm). Two graduate students, already trained in the techniques relevant to this project, will lead the optimization, fabrication, and testing of these optoelectronic components. Up to three undergraduate students will also be involved with the research. A wide swath of astrophysical research, from spectroscopic studies of the distant universe to searches for biosignatures in the atmospheres of exoplanets, stands to benefit from these miniature spectrometers and filters on board future NASA balloon, CubeSat, Explorer, Probe-, Flagship-, and Surveyor class missions. The technical by-products of this effort will also offer benefits in fields far beyond astronomy, such as medicine, human science, petrochemistry, space geo-science, and quantum computing and communication. The names and contact information of five experts qualified to review this proposal were emailed directly to the two

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

University of Maryland-College Park (UMCP)

Responsible Program:

Astrophysics Research and Analysis

Miniature Photonic Spectrometers and Filters for Astrophysics and Space Science

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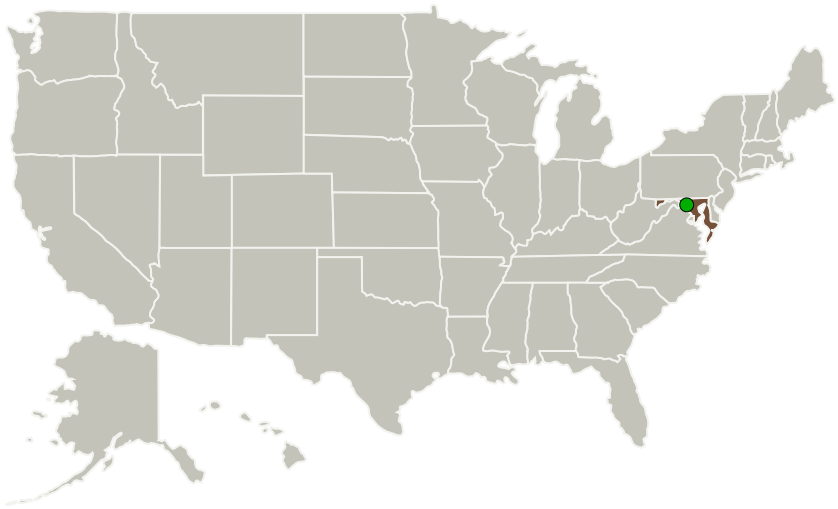
relevant Program Officers.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Maryland-College Park(UMCP)	Lead Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	College Park, Maryland
Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland
University of Sydney	Supporting Organization	Academia	Sydney, Australia

Primary U.S. Work Locations
Maryland

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Sylvain Veilleux

Co-Investigators:

Matthew A Greenhouse
Stuart N Vogel
Mario Dagenais
Samuel H Moseley
Alexander S Kutyrev
Joss Bland-hawthorn
John C Mather
Bernard J Rauscher
Andrew I Harris
Stephanie M Swann
L. D Deming
Stephen B Cenko

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System